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ABSTRACT

This paper attempts to make the case for incorporating writing into the science curriculum. Suggestions are offered on how to organize writing activities in the classroom, assess a student's writing skills, use writing experience charts in science, outline content in science, write results from science experiments, write book reports, perform journal writing in science, write diary entries, write log entries, and use word processors. It is recommended that the science teacher provide a variety of writing activities for students in order to meet individual differences and contends that writing is basic in the curriculum. (DDR)

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WRITING AND THE PUPIL IN THE SCIENCE CURRICULUM

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Pupils need to become quality communicators of content in writing. Why? Scientists in a laboratory setting must be able to write their findings in an accurate, objective approach so that effective communication among experts, as well as others, is in evidence. Not being able to communicate effectively in writing would greatly hinders scientific achievement in sequence on a continuing basis. Thus, in poorly developed written communication, scientists could not benefit from each other's research and findings. It behooves the teacher to encourage, assist, and motivate each pupil to do as well as possible in writing in ongoing science units of study.

Pupils may engage in writing on an individual or committee basis. Pertaining to committee or cooperative learning endeavors, Ediger (1997) wrote:

Cooperative learning is receiving considerable emphasis in curriculum development. It is difficult to say how cooperative learning is different from the earlier term "committee endeavors" stressed in curriculum development. Presently, it appears that most writers and speakers in education recommend using cooperative learning rather heavily in the classroom. Thus, pupils in a class work cooperatively in projects, activities, and experiences. The teacher becomes a guide or assistant to help learners achieve as much as possible. It is important here to emphasize that pupils work as a unit, not separately. Quality group dynamics becomes salient in cooperative learning. Learners then need to achieve goals and be goal centered. Competition among individuals is deemphasized and cooperation is salient. Individuals may work on different tasks in a team setting; however, these endeavors should represent cooperation in goal attainment.

Why is cooperative learning important? Presently, as well as in the future work place, individuals will be asked to work harmoniously with others. The individual who cannot work well with others will be handicapped. There are people from diverse cultures and abilities in any work place. Thus a pupil presently should be able to work with children of different values and talents. Being able to accept others is of utmost importance. Pupils individually need to be responsible to contribute optimally in cooperative endeavors. They need to think of themselves as a part of a group, not as competitive individuals. At issue here is how much time should be placed upon cooperative learning as compared to individual achievement. To think about individual

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endeavors in the curriculum, one must admit this is also important. Each person interacts with others and yet also needs to be able to use spare time wisely on an individual basis. A person is not a member of a group always but is also a person who has unique interests, needs, and purposes.

Writing and the Pupil

The science teacher needs to determine where each pupil is presently in achievement in writing. At this starting point, the teacher must guide learners on an individual basis to attain optimally and in a sequential manner.

A. Writing Experience Charts in Science

Early primary grade pupils tend to enjoy writing experience charts. A cooperative teacher who supervised a student teacher of mine taught a unit on Animals in Our Lives. She had three goldfish in an aquarium, tadpoles in a jar, a frog in a terrarium, a small garter snake in a different terrarium, and a pet canary in a bird cage. Pupils observed the goldfish carefully as they swam in the aquarium. Pupils were then asked to present ideas on what they saw to the teacher who in return recorded in writing observations presented. The following sentences, among others, were given in which first grade learners could see talk written down and experience writing:

1. The gold fish swam rapidly.
2. The bright colors mixed with the sunlight.
3. Water in the aquarium has bubbles inside of it.
4. Fish come up to breathe air.
5. It is fun to watch the fish being fed.

The numerals were then removed form the above experience chart and pupils read the content with teacher guidance. The teacher pointed to the words as the young learners orally read the content together with the teacher. There were numerous pupils who could not read the subject matter initially, but developed confidence to do so as the teacher patiently pronounced the words sequentially in the group exercise using

the experience chart. The experience chart was saved and posted on the wall. Pupils could then view the chart as the need arose. A week later, the teacher again read the contents of the chart with the children involved. Several asked to read it individually to the entire class. This developed considerable enthusiasm. The teacher announced to the class that anyone wishing to read the contents off the chart to her (the teacher) should do so at any time. At this point and stage of achievement, most of these first grade pupils read the subject matter on the chart, making very few errors. This chart and later ones developed were saved for learners to reread at their own convenience.

With the use of the experience chart approach in teaching writing, pupils can see talk written down. Thus what is said orally can be printed with the use of abstract symbols in grapheme- phoneme relationships. The experience chart concept of teaching reading is based upon learners having a personal experience. In this situation, the experience was to look at goldfish. Later experience charts would be based upon pupils seeing tadpoles, frogs, a snake, and a canary. This brought to the attention of pupils, fish, amphibians, reptiles, and birds as sequential classification of animals with backbones. Still later, the teacher brought her pet cat to class to show a mammal.

With concrete experiences of viewing lifelike, real animals, pupils began to use language to describe what was viewed. The use of oral communication was then inherent. Pupils listened to the ideas presented by others. The content that resulted was printed in neat, manuscript letters by the teacher. Learners then read the content orally with teacher guidance as the latter pointed to the words and phrases within each sentence. Thus oral communication, listening, writing, and reading were experienced by each learner. The four language arts areas then become an inherent part of the science unit currently being studied.

When pupils are ready, they should write their own experience charts. This activity can be appropriate on any grade level.

Art work may well be related to writing experiences for pupils. Ediger and Rao (1996, pages 91-92) wrote:

Learning activities involving art work can do much to enrich the elementary school science curriculum. Thus, the science teacher must provide a variety of of learning experiences involving art in the science program.

1. Developing murals. Pupils in a committee may plan and develop a mural pertaining to to an ongoing unit of study in science. Thus, if pupils, for example, are studying a unit on "Animals with Backbones," they may decide upon scenes involving-

a. diverse kinds of fish.

b. amphibians, e.g. toads and frogs.

c. reptiles, e.g. snakes and turtles.

d. various kinds of birds.

e. mammals, e.g. human beings, monkeys, chimpanzees, gorillas.

2. Developing friezes. A series of pictures developed by a committee of pupils is inherent in cooperative planning and implementing the frieze concept in art work. A variety of media should be available to pupils when working on a frieze. Thus, crayons, colored chalk, water colors, colored pencils and finger paints should be readily accessible at the frieze center. If pupils, for example, are studying a unit on "Animals Without Backbones," they may develop a series of illustrations (a frieze) on—

a. protozoans, e.g., the amoeba, the paramecium, and the euglena.

b. porifera (sponges).

c. coelenteratas, e.g. hydras, jellyfish, coral, and sea anemones.

d. platyhelminthes (flatworms) e.g. planarian, flukes, and tapeworms.

e. aschelminthes (roundworms), e.g. hookworms, ascaris, and the trichinellla.

f. annelida (segmented worms) e.g. earthworm and sandworm.

g. echinodermata (spiny animals) e.g. star fish, the sea urchin, the sea cucumber, and the sand dollar.

h. molusca (shellfish) e.g. clams, scallops, oysters, snails, and slugs.

i. arthropods, e.g. shrimp, lobsters, crayfish, and crabs. Insects are also members of this phylum— praying mantis, grasshopper, walking stick, dragonflies, ladybugs, and potato beetles.

B. Outlining Content in Science

Outlining content read from the basal or other reference source might well assist pupils to be able to organize information better in terms of sequence. A quality outline should possess the following parts:

1. The title
2. Roman numerals to show the main ideas or divisions
3. Capitol letters under each main idea to show the relationship of these subdivisions with the main idea
4. Details with ordered numerals under each subdivision to show relationships between the subdivision and the related details.

In outlining content, such as from the basal textbook in science, pupils may perceive the relationship of subordinate ideas to the main idea, the details to the subordinate idea, and the general sequence of subject matter. A pupil that focuses too much upon isolated facts tends to forget content sooner as compared to those who perceive that broader ideas exist such as subordinate and main ideas. Then too, broader ideas tend to become a part of the general repertoire of the learner sooner as compared to the acquisition of isolated facts. Thus, there is a structure of knowledge in science for the learner when he/ she perceives that key ideas can be selected and subordinate content and details can be related rather readily to the main ideas. I recommend that when pupils are ready, not before, they experience practice in outlining subject matter, not for the sake of doing so, but to perceive knowledge as being related.

A quality outline on a purposeful topic provides the learner with an excellent tool to present an oral report to others in the classroom setting. The pupil should never read ideas from an outline, but use the ideas therein to present well organized subject matter to listeners. Thus, if the learner forgets sequential content in the report, he/she may then refer to the outline. Quality organization of content assists the listener to acquire what is being presented. If an oral report contains randomly presented ideas, the chances are that comprehension by listeners will be difficult.

Pupils may receive practice in reading content in science that is poorly organized and rearrange the sentences so that coherence is in evidence. Noticing the differences between the two is important.

Writing Results From Science Experiments

A very useful writing experience for pupils is to write up science experiments that have been or will be performed in ongoing units of study. I believe that a plan developed by the teacher with pupil involvement will aid in writing that which is clear and distinct. First of all, the experiment needs to have a title which is meaningful to readers. If pupils are studying a unit or partial unit on water erosion of soil, a science experiment that is salient might well be entitled " Water and Soil Erosion." A problem then needs to be stated. The problem should be written clearly so that related information may be located as solutions. Hazy problem areas do not lend themselves to finding needed answers. A clearly worded problem might be the following: How does rainfall affect the soil in our schoolyard? Learners might then brainstorm answers to this question. No value judgment should be made of contributions of individual pupils. Respect for the thinking of others is necessary to generate ideas. The answers proposed in brainstorming should be recorded on the chalkboard to avoid unnecessary duplications. Higher levels of cognition are involved when pupils continue to offer answers. Initially, it probably is relatively easy to offer answers to the identified problem or question. After brainstorming, pupils need to ascertain which answers are acceptable and which are not. Science experiments should be performed in the classroom to determine the affects of water upon soil as well as observing in the out-of-doors what happens to soil with different levels of intensity of falling rain. As many variables as possible must be observed too, such as the slope of the land, the covering (grass) of the soil, and the kind of soil (clay, sandy, loam, among others). Inside the classroom, two boxes of equivalent soil with equal slope may be used initially. A similar amount of water should be poured over each box containing the soil. The only variable tested here is that one box has a grass covering over the soil whereas the other box does not. The amount of runoff of the soil for each box may be determined with a small container as broad as each box at the base to catch the eroded soil. Other variables to test for include different cover crops, different kinds of soil, as well as different amounts

of water with variable intensity poured over each box.

These activities can also be used in testing the different answers given in brainstorming:

1. reading from diverse sources which shed light on water erosion of soil.
2. viewing audiovisual aids on causes and prevention of erosion of soil.
3. listening to qualified resource persons.
4. doing additional experiments and observing demonstrations.
5. making models of soil preservation including terracing, strip cropping, and trees/vegetative coverings to prevent erosion in its diverse forms.

Answers to questions should be viewed as tentative with chances of making necessary modifications as the need arises. Each step discussed above should be written with clarity and precision. Thus the problem or question, the brainstormed ideas, the data gathering, and needed modifications sections should be written with meaning and comprehension. Quality writing assists in communicating ideas more effectively.

A long standing debate has been in evidence in the teaching of science as to should it stress processes or products. A very popular approach in teaching science is Science— A Process Approach (SAPA) developed by the American Association for the Advancement of Science (no date given); their advocated objectives are the following processes:

1. observing
2. recognizing and using number relations
3. measuring
4. recognizing and using space time relations
5. classifying
6. communicating
7. inferring
8. predicting
9. defining operationally
10. formulating hypotheses
11. interpreting data
12. controlling variables

13. experimenting.

The science teacher may stress the above named SAPA with or without using their materials of instruction. For example, objective number one above which is observing is very important in all science units of study. Here, the teacher may emphasize pupils observing a science experiment and all the sequential steps therein. The teacher may then appraise if pupils are observing carefully. This may be determined by teachers viewing attentiveness of learners during an experiment. Pupils might reveal their observational skills by writing up what happened sequentially in the ongoing experiment.

D. Writing Book Reports

Summarizing what has been read from a library book directly related to an ongoing science unit can be highly educational for pupils. The learner should have had the opportunity to choose his/her own book to read, from among others, at a reading center. There are several kinds of writing activities that can be implemented here. The pupil needs to select which procedure to use when writing about subject matter read from a library book. Thus, the pupils may choose from among the following:

1. writing a certain number of main ideas covered in the chosen book.

2. writing what was perceived to be the most interesting content contained in the reading material.

3. writing one or more paragraphs pertaining to the central idea contained in the library book.

4. writing questions that remain unanswered pertaining to the

content.

5. writing a different beginning or ending if the contents of the library book are highly creative, such as the book Miss Pickerel on Mars.

Writing summaries pertaining to content read from library books should encourage, not destroy interest, in reading and writing content in science. The teacher should evaluate achievement here and in all writing experiences based on the following criteria:

1. use standards that assist the learner to notice that which needs to be improved upon.

2. have reasonable standards for each pupil, not excessively difficult nor at too low a level of achievement.

3. do not emphasize too many corrections for any one pupil to make, lest the involved child is overwhelmed with corrections that need to be made.

4. focus upon ideas in the written product, not exclusively upon the mechanics of writing such as spelling, punctuation, and grammar.

5. emphasize clarity of ideas expressed, not quantity in content written.

It is important for teachers to have conferences with pupils, one on one, too assist learners to improve over previous attempts at written work. The conference should stress caring for the pupil in becoming a better writer. Negative criticism must be avoided in the conference setting. A positive attitude toward the learner and his/her ability to improve in writing in all school endeavors is a must. Ediger (1996) wrote:

Relevant principles of psychology in teaching and learning must be followed when pupils engage in ongoing units of study... in the science curriculum. Thus, experiences for pupils should follow these standards or criteria:

1. learning activities should be interesting and meaningful.

2 pupils must have needed background information and possess adequate readiness for new units of study.

3. learners should perceive purpose in learning in ongoing units of study.

4. each pupil should be guided to achieve optimal development in understandings, skills, an attitudinal objectives.

5. learner progress must be continuously evaluated to determine progress in achieving stated objectives.

E. Journal Writing in Science

Pupils need to be given time to engage in journal writing. this provides opportunities for learners to reflect upon what has been learned in ongoing science units and lessons. Journal entries may be dated. What is written in the journal is up to the pupil. A pupil may then write what transpired in a science experiment or demonstration. The learner may wish to focus upon salient ideas discussed in a committee setting. With reflection, the involved learner will remember better what has been learned due to thinking upon key ideas or concepts stressed in science. The pupil might desire to write about attitudes and interests developed in science as a result of teaching and learning experiences.

Should the teacher appraise the quality of these journal entries? If not, how does a teacher know if the time devoted to journal writing is worthwhile and assists the learner to attain relevant objectives? If the teacher appraises the quality of journal writing, should the contents be graded? These and other vital questions need careful consideration.

I would suggest that teachers encourage pupils to share their writings. This can be done by sharing content written with the teacher on a voluntary basis. Pupils might also meet in committees to share what has been written. It is best if pupils are not coerced to show what was written in the journal. However, a pupils may waste time and pretend he/she is writing, but is day dreaming or writing irrelevant content. I believe the teacher can and must observe pupils to notice that achievement is taking place in all learning opportunities. A general overview in observing learner achievement may suffice in appraising pupil progress in writing journal entries. The teacher needs to be a good observer and use quality criteria to appraise pupil progress. A listing of criteria may assist the teacher to make justifiable decisions pertaining to pupil journal writing. Among others, these include the following:

1. time on task is vital.

2. conscientious and judicious statements are a must.

3. proper order of written subject matter is salient.

4. clarity of content is necessary.

5. accurate mechanics in writing are needed to the degree it makes the written content more meaningful.

There should be a variety of kinds of learning opportunities in writing so that pupils feel that written work is utilitarian and purposeful.

F. Writing Diary Entries

Pupils individually or in committees need to have ample opportunities to write on a day to day basis what was learned in a science lesson. Each entry should be dated. By writing what was learned on a daily basis in science, writers review previously acquired information. With review, subject matter learned will be retained for a longer period of time than would otherwise be the case. Pupils should participate on a rotating basis in writing these diary entries. The following are examples of diary entries written by a committee of learners:

October One. The teacher explained to us the differences between sheet and gulley erosion. Emphasis was also placed upon the amount of top soil lost each year due to erosion. Farm crop yields decrease when rich top soil is not available for the growing of wheat, soybeans, and corn, among other grains. Marginal and tilled hilly land, in particular, are subject to increased erosion.

October Two. We went outdoors to notice gulley erosion beginnings on our playground. We leveled the soil and seeded grass to avoid erosion. We then came into the classroom to watch a video-tape on "Preventing soil Erosion." Before observing the video, we hypothesized on ways to prevent soil erosion. During the video, we were asked to list and describe different ways to prevent or minimize soil erosion as presented in the video. These ways include using terraces, seeding grass and planting trees, as well as emphasizing strip cropping, among others.

The teacher may discuss with the entire class what might be added to each diary entry. These entries should be kept so that pupils might use these for review. Individual or committee members' names may appear on each page of diary entries and bound for future reference. Hopefully, the learning opportunity will increase learner interest, purpose, and meaning for writing in science.

G. Writing Log Entries

Pupils may review and combine the diary entries so that a log may be written. A log covers a longer period of time in terms of lesson content as compared to diary entries. Thus a log may pertain to recording what was learned within a week. The diary entries then become a part of the log. Individuals and committees who record the log entries must read carefully each diary entry so that broader generalizations may be written such as in a log. Log entries should be bound together with the diary entries so that pupils might review and rehearse what had been learned previously. Log entries provide a good basis in reviewing for an oncoming test.

Standards to follow in writing log entries include the following:

1. ideas should be specific enough so that misinterpretation is not possible.

2. quality human relations need to be stressed in any committee endeavors.

3. appropriate order of content is necessary so that sequence is in evidence.

4. correct spelling of words, punctuation, indentation of paragraphs, and grammar should be in evidence in order to communicate effectively. However, the focal point is on ideas in the logs, not the mechanics of writing.

5. log writing must encourage an increased desire to write rather than writing being perceived as a chore.

If pupils are to become good writers, writing should be emphasized

across the curriculum. The curriculum area of science provides its many opportunities for pupils to become good writers. The are numerous purposes in writing in science. The author here recommends that pupils participate actively and fully in written work in ongoing lessons and units of study in science.

Using Word Processors

One of the greatest boon to writing has been the use of the word processor. The word processor indeed eliminates much drudgery attached to writing. The mistakes made in typing can quickly be corrected on the monitor before a final copy is sent through the printer. One can secure the desired copy, reading it on the monitor, before printing occurs. A perfect copy may then result even if a person's typing is not the best. A spell check program eliminates spelling errors in a hurry without retyping any part of the document. There are limitations here in that the computer does not catch errors in homonyms nor in selected other kinds of errors such as in punctuation or capitalization. The user of the word processor still needs to be able to proof read typed content carefully and oh so carefully. However, spelling errors can all be taken care of in a very short time indeed with a spell check program. Typing errors can be taken care of quickly by looking to see what is on the monitor and making needed revisions when proofing. I find it enjoyable to use a word processor in typing manuscript content each day. One can make much headway in typing with a personal computer that is very user friendly. A person who can type using the old typewriter can learn very quickly to use a word processor and be amazed at its capabilities!

Pupils who use word processors, when ready, feel ownership of the tasks involved thereon. The pupil with teacher assistance determines the content to be put into the computer. He/she sequences the content to be typed. Revisions are made in terms of the writer's goals. When changes need to be made such as rearrangement of ideas in the typing, this can be done quickly. No longer does a writer need to start all over in typing a page if a single error has been made. Whiteout

does not need to be used in making corrections as was true of typewriter use. The writing curriculum must be updated so that each learner can benefit from modern technology and its applications. With word processors, the following conclusions may well be emphasized:

1. writing tends to be more enjoyable since errors made can quickly and conveniently be corrected with user friendly technology.

2. the rearrangement of ideas for quality sequence can be rapidly implemented, making it unnecessary to start over again in the typing process.

3. pupils may feel that what is done using the word processor is completely in their hands. The pupil gives the commands to the computer and completely controls what will follow in terms of content and the mechanics of writing.

4. content typed can involve diverse purposes such as formal and creative writing. Each of the purposes discussed throughout this manuscript pertaining to writing may be emphasized using the word processor.

5. pupils individually or in dyads may write using the word processor depending upon goals stressed in writing in science. Goals may stress individual as well as group or committee endeavors in the curriculum.

In Closing

The science teacher needs to provide a variety of writing activities for pupils. This is necessary to provide for individual differences. Pupils should be guided to become increasingly proficient in writing. One cannot expect a pupil to blossom immediately into becoming a good writer. Rather, sequentially, each pupil can build a repertoire of writing skills. By comparing a pupil's past written product with his preset written work, the teacher can notice the degree to which a learner is achieving more fully. Writing is a basic in the curriculum. The science teacher should incorporate writing experiences when it assists pupils to acquire more subject matter content. Acquisition of facts, concepts, generalizations, principles, and laws of science are vital. So too must

skills objectives be emphasized in teaching- learning situations. Thus writing for a variety of purposes in science is salient. The science teacher needs to notice if quality attitudes are a byproduct of subject matter and skills stressed in the science curriculum. Each pupil is unique in achievement and needs adequate provision so that continuous progress is possible in science. Pertaining to stressing a variety of writing activities in science, Ediger and Rao (1996, pages 86-90) summarized the following:

1. develop an outline. Each pupil with teacher guidance may develop an outline pertaining to content that has been read relating to an ongoing unit of study...
2. develop a written report. The content of the outline may be used to develop a written report. Written reports may deal with -
   a. summaries of experiments conducted in ongoing units of study in science.
   b. diary entries kept by pupils on a daily basis pertaining to understandings, skills, and attitudes acquired. Members on a committee may be rotated in writing these diary entries...
3. write poetry such as haiku, free verse, couplets, triplets, and quatrains...
4. Other forms of written work such as writing plays, announcements, and notices, as well as writing biographies of famous scientists.

A variety of kinds of written work should be emphasized so that pupils learn to communicate clearly and accurately in science.

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